

BROOKLYN COLLEGE

Department of Chemistry

Chemistry 2

First Lecture Exam

Spring 2003

Name \_\_\_\_\_

Circle the name of your lab instructor

Kazimierska, Girotto, Voloshchuk

**Before** you begin the exam, write your name on this page and on the answer booklet.**WARNING: There are questions on BOTH sides of each page. Do NOT tear off this page.**

Answer Questions 1-12 on the question sheet. Do questions 13-24 in the exam booklet.

For questions 13-24, show all work. Express answers with the proper units and to the correct number of significant figures. You have 90 minutes. Do not spend too much time on one question.This exam has 4 pages. Make sure you have all of them. Calculators may be inspected.

## PERIODIC CHART OF THE ELEMENTS

IA	IIA											IIIA	IVA	VA	VIA	VIIA	0	
1 H 1.0079																	1 H 1.0079	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179	
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948	
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.905	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29	
55 Cs 132.91	56 Ba 137.33	57 * La 138.90	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra 226.0	89 # Ac 227.03																

* Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
# Actinides	90 Th 232.03	91 Pa 231.03	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (257)	102 No (255)	103 Lr (256)

Name \_\_\_\_\_

**Answer Questions 1–12 on these sheets.**

1. (2 pts) Which one of these ions is the weakest base?

- (a)
- $\text{C}_2\text{H}_3\text{O}_2^-$
- (b)
- $\text{OH}^-$
- (c)
- $\text{NO}_3^-$

2. (10 pts) State whether each of the following is True or False.

- (a) When the reaction  $\text{A} \rightleftharpoons \text{B}$  has reached equilibrium, the concentration of the substance A must equal the concentration of the substance B.
- (b) A reaction with a very high activation energy will have a low rate of reaction.
- (c) The rate constant  $k$  of a reaction changes when the concentrations of the reactants change.
- (d) The rate constant  $k$  of a reaction changes when the temperature changes.
- (e) Reaction orders are always whole numbers (integers).

3. (4 pts) (a) Give the formula of the conjugate base of  $\text{HSO}_4^-$  (note the charge).(b) Give the formula of the conjugate acid of  $\text{HSO}_4^-$ .

4. (6 pts) Classify each of these solutions as acidic, basic, or neutral.

- (a)
- $\text{NH}_4\text{NO}_3(\text{aq})$
- (b)
- $\text{KCl}(\text{aq})$
- (c)
- $\text{CuSO}_4(\text{aq})$

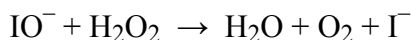
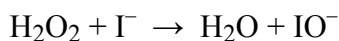
5. (6 pts) A student adds water so as to double the volume of a solution of  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$ , while keeping the temperature and pressure constant.(a) Does the addition of water cause the reaction quotient  $Q$  for the acid ionization to increase, decrease, or remain the same?(b) Does the addition of water cause  $K_a$  to increase, decrease, or remain the same?Answer questions (a) and (b) for the instant after the water is added but **before** the equilibrium shifts.

- (c) When the system reaches the new equilibrium position, will we have more  $\text{C}_2\text{H}_3\text{O}_2^-$  ions, less  $\text{C}_2\text{H}_3\text{O}_2^-$ , or the same amount of  $\text{C}_2\text{H}_3\text{O}_2^-$  than was originally present?
6. (3 pts) When  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$  is titrated with  $\text{NaOH}(\text{aq})$  at  $25^\circ\text{C}$ , the pH at the equivalence point
- (a) is less than 7.0    (b) is equal to 7.0    (c) is greater than 7.0
7. (2 pts.) In the reaction  $\text{Cr}^{3+}(\text{aq}) + 6\text{H}_2\text{O} \rightarrow \text{Cr}(\text{H}_2\text{O})_6^{3+}(\text{aq})$ , the Lewis acid is
- (a)  $\text{Cr}^{3+}$     (b)  $\text{H}_2\text{O}$     (c)  $\text{Cr}(\text{H}_2\text{O})_6^{3+}$     (d) There is no Lewis acid in this reaction.
8. (3 pts) We add a certain volume of 0.10 M  $\text{NH}_3(\text{aq})$  to 50 mL of 0.10 M  $\text{HCl}(\text{aq})$ . Which one of these  $\text{NH}_3(\text{aq})$  volumes will produce a buffer solution?
- (a) 25 mL    (b) 50 mL    (c) 75 mL    (d) None of these volumes will give a buffer solution.
9. (2 pts) A certain aqueous solution at  $25^\circ\text{C}$  has  $[\text{OH}^-] = 8 \times 10^{-9}$  M. This solution is
- (a) acidic    (b) basic    (c) neutral
10. (2 pts) Write the equilibrium that occurs in an aqueous solution of the weak base  $\text{CH}_3\text{NH}_2$ .
11. (2 pts) In aqueous solutions, the un-ionized weak acid  $\text{HX}$  is green and the anion  $\text{X}^-$  is yellow. When one drop of  $\text{HX}(\text{aq})$  is added to 1 M  $\text{HNO}_3(\text{aq})$  (which is colorless), what color does the solution become?
12. (3 pts) A solution is 0.10 M in  $\text{HCN}$  and is 0.20 M in  $\text{HBrO}$ , where these are both weak acids. The  $K_a$  expression for  $\text{HCN}$  is  $K_a = \frac{[\text{H}^+][\text{CN}^-]}{[\text{HCN}]}$ . Which statement is true?
- (a) The  $[\text{H}^+]$  in the numerator of  $K_a$  includes *only* the  $\text{H}^+$  that comes from the ionization of  $\text{HCN}$ .
- (b) The  $[\text{H}^+]$  in the numerator of  $K_a$  includes the  $\text{H}^+$  that comes from the ionization of the  $\text{HCN}$  *and* also the  $\text{H}^+$  that comes from the  $\text{HBrO}$  ionization.

**Answer Questions 13-24 in the answer booklet. Show all work.**

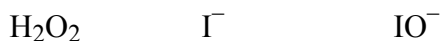
**You are NOT allowed to use the Henderson-Hasselbalch equation**

13. (3 pts) The reaction  $R + S \rightarrow \text{products}$  is first order in R and is second order in S. At 25°C, when the initial R concentration is 0.20 M and the initial S concentration is 0.30 M, the initial rate of this reaction is  $4.0 \times 10^{-4} \text{ M s}^{-1}$ . Find the rate constant for this reaction at 25°C.
14. (4 pts) At 500°C, the reaction  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$  has  $K_P = 0.72$ . ( $K_P$  is called  $K_{\text{eq}}$  in the textbook). In a certain system that is **at equilibrium** at 500°C, the  $\text{H}_2$  partial pressure is 0.70 atm and the  $\text{NH}_3$  partial pressure is 0.20 atm. Find the  $\text{N}_2$  partial pressure in this equilibrium system.
15. (8 pts) A certain reaction has the following two-step mechanism:



(a) Write the overall reaction. (Reminder: Answer in the exam booklet.)

(b) State whether **each** of these species is a reactant, a product, an intermediate, or a catalyst:



16. (2 pts) At 500°C,  $K_{\text{eq}} = 4.0$  for  
 $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$ .  
 Find  $K_{\text{eq}}$  at 500°C for  
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$ .

17. (2 pts) If  $\log x = -1200.560$ , find  $x$ .

18. (6 pts) Several experiments for the reaction  $A + B + 2C \rightarrow \text{products}$  gave these results

Experiment	Initial [A]	Initial [B]	Initial [C]	Initial rate
1	0.20 M	0.40 M	0.10 M	1.2 M/s
2	0.20 M	1.60 M	0.10 M	4.8 M/s
3	0.20 M	0.80 M	0.20 M	9.6 M/s
4	0.40 M	0.80 M	0.20 M	9.6 M/s
5	0.20 M	0.40 M	0.30 M	10.8 M/s

Find the order with respect to A. Find the order with respect to B. Find the order with respect to C. When you find each order, you **must** state which two experiments you are using to find that order. (Do **not** find the rate constant.)

19. (6 pts)  $K_{sp} = 2 \times 10^{-19}$  for  $\text{LaF}_3$  in water at  $25^\circ\text{C}$ . How many grams of  $\text{LaF}_3$  are present in 500 mL of saturated  $\text{LaF}_3(\text{aq})$  at  $25^\circ\text{C}$ ? The atomic weight of La is 139.
20. (7 pts) Find  $[\text{H}^+]$  in 0.25 M  $\text{NaC}_2\text{H}_3\text{O}_2(\text{aq})$  at  $25^\circ\text{C}$  given that  $K_a = 1.8 \times 10^{-5}$  for  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$  at  $25^\circ\text{C}$ . You **MUST** begin by writing the chemical reaction that is at equilibrium.
21. (4 pts) Find  $[\text{H}^+]$  in a solution prepared by dissolving 1.50 g of  $\text{Ca}(\text{OH})_2$  in 600 mL of water and diluting the solution to a final volume of 800 mL.
22. (1 pt) Find  $[\text{H}^+]$  in a solution with pH 5.43.
23. (6 pts) Find the pH when 45.0 mL of 0.250 M  $\text{NaOH}(\text{aq})$  is added to 35.0 mL of 0.200 M  $\text{HCl}(\text{aq})$ .
24. (6 pts) Find  $[\text{H}^+]$  in a solution prepared by adding 0.40 moles of  $\text{NaCN}$  to 500 mL of a 0.25 M  $\text{HCN}(\text{aq})$  solution. Assume that there is no volume change when the  $\text{NaCN}$  is added. For  $\text{HCN}(\text{aq})$ ,  $K_a = 4.9 \times 10^{-10}$ .

**Reminder: Any work on any problem you did using the Henderson-Hasselbalch equation will earn you no credit.**

**Extra credit** – Answer in the exam booklet

EC1 (2 pts) Given that  $x$  must be positive, solve this equation for  $x$ :

$$\frac{2x^2}{0.40 - x} = 0.30$$